**Characterization of optically shaped gas-jet target profiles for proton acceleration experiments in the near-critical density regime**

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Laser-induced proton acceleration has attracted increasing attention due to its numerous potential applications such as in Inertial Fusion Energy (IFE) for the proton-driven fast ignition scheme and in biomedical applications (i.e., hadron therapy). Laser-plasma accelerators are often based on the interaction of an intense laser pulse with a solid target, in the over-dense plasma regime. The targets are destroyed upon irradiation, not allowing their use for high repetition rate (HRR) proton sources. Extreme-pressure gas-jet targets, able to reach the near-critical (NCR) density plasma regime, can be used as HRR, debris-free proton sources. State-of-the-art simulations predict hundreds of MeV protons by Magnetic Vortex Acceleration (MVA) [1]. MVA remains experimentally challenging for super-intense, short wavelength, femtosecond laser pulses due to the steep density gradient plasma profiles required. Here we present an experimental characterization of high-pressure, supersonic gas-jet density profiles performed using Mach-Zehnder interferometry. The NCR density profiles are delivered by 3D printed specially designed nozzles with a solenoid valve along with an air-driven hydrogen gas booster, able to support up to 1000 bar of backing pressure. We further present their optical shaping through multiple, laser-generated blastwaves (BW) [2] using ns pulses from an 840 mJ Nd:YAG laser. The counterpropagating BWs compress the gas-jet targets, upon their shock fronts’ collision, achieving steep density gradient slabs of a few microns thickness. These profiles are considered suitable candidates for laser-induced proton acceleration experiments, using the 45 TW, fs laser system ZEUS [3], hosted at the Institute of Plasma Physics and Lasers (IPPL). Finally, we present MagnetoHydroDynamic simulation results on the optical shaping of the gas-jet target profiles by multiple laser pulses geometrical set-ups [4].

**Acknowledgments**

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

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